GYNANDROMORPH OF *HELICOVERPA ARMIGERA* [LEPIDOPTERA : NOCTUIDAE][1]

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ABSTRACT: A gynandromorphic moth was observed in a laboratory culture of the American bollworm, *Helicoverpa armigera*, with external characters of female on the left and of male on the right side. Dissection revealed the presence of a testis and an ovary on the trans-lateral positions of the moth, respectively.

A gynandromorph is an individual in which one part of the body is masculine and the other is feminine. Among insects, bilateral gynandromorphs are most frequent, in which the left and right halves are of different sexes (Mayr and Ashlock, 1991). However, anteroposterior gynandromorphs and forms with irregular mosaic-like distributions of sexual characters also are known (Richards and Davies, 1977).

In *Drosophila melanogaster* of XX chromosomal constitution, a gynandromorph arises through the loss of one X chromosome in one of the early cleavage nuclei of the embryo, so that deficient (XO) cells form male tissue while those with a full complement of sex chromosomes yield female tissues (Wilbert, 1953). Gynandromorph also can result from the "double fertilization" of abnormal eggs possessing two nuclei, one of which gives rise to male and the other to female tissues (White, 1968). Some parasitic Hymenoptera yield many gynandromorphs at unusually high temperatures (Bowen and Stern, 1966).

Lepidopteran gynandromorphs have been recognised in species with sexual dimorphism where the male has coloration and/or pattern elements that typically differ from those of the female. Hence, notable sexual differences in phenotype appear on the two halves of the adult. An extraordinary hybrid gynandromorph containing wing-pattern genes from at least three subspecies of *Heliconius melpomene* (Lepidoptera : Nymphalidae) was reported by Emmel and Boender (1990). A rare gynandromorph of *Nacophora quernaria* (Lepidoptera : Geometridae) from Florida showed a perfectly bilateral division between the male and female with different antennae, the thorax, and the posterior anal tufts of the abdomen (Kutis and Heppner, 1990).

At the Division of Entomology, Indian Agricultural Research Institute, New Delhi, a gynandromorph of *Helicoverpa armigera* arose for the first time in a laboratory colony reared on the artificial diet of Singh and Rembold (1992). Incidentally, this has been observed in a routine experiment with plumbagin, a napthaquinone of plant origin having insect growth regulatory activity, where the larva received a dose of $100 \mu g\ g^{-1}$ applied topically.

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Over 20 generations, the normal coloration of the moths in the laboratory culture is unaffected by the diet and they perfectly resembled those collected at light or those emerged from larvae collected from chickpea, pigeonpea and cotton fields. The female moth of *H. armigera* is dull orange-brown with a 'V' shaped marking on forewing and dull black border on the hindwing. Forewing of male is greyish-green and poorly marked beyond the transverse posterior line (Hardwick, 1965).

The single gynandromorph specimen observed had an orange-brown colored forewing on the left side and greyish-green colored forewing on the right. The color pattern fits perfectly with that of a female on the left and male on the right. The posterior anal tufts of the abdomen were prominent on both sides [Fig. 1]. Dissection of the moth revealed the presence of a testis and accessory glands on the left side and an ovary and colleterial glands on the right side [Fig. 2]. The placement of sex organs is therefore opposite to that of the sexual differences in the external color pattern. The specimen is unique in this regard. Though the moth survived for over one week on 10% honey solution, it is not known if the moth might have been reproductively viable. Examination of the moths of this species from the National Pusa Collection of our Division has not revealed the occurrence of any specimen with such a mosaic of external coloration.

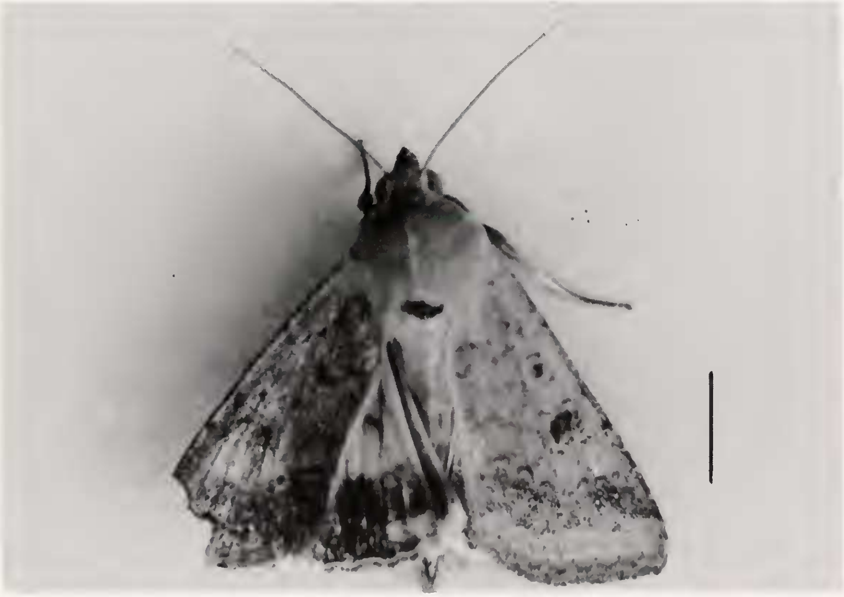

Fig. 1 Gynandromorph of *Helicoverpa armigera* (Hubner) Left side forewing : female pattern, right side : male pattern (Scale line = 0.5 cm).

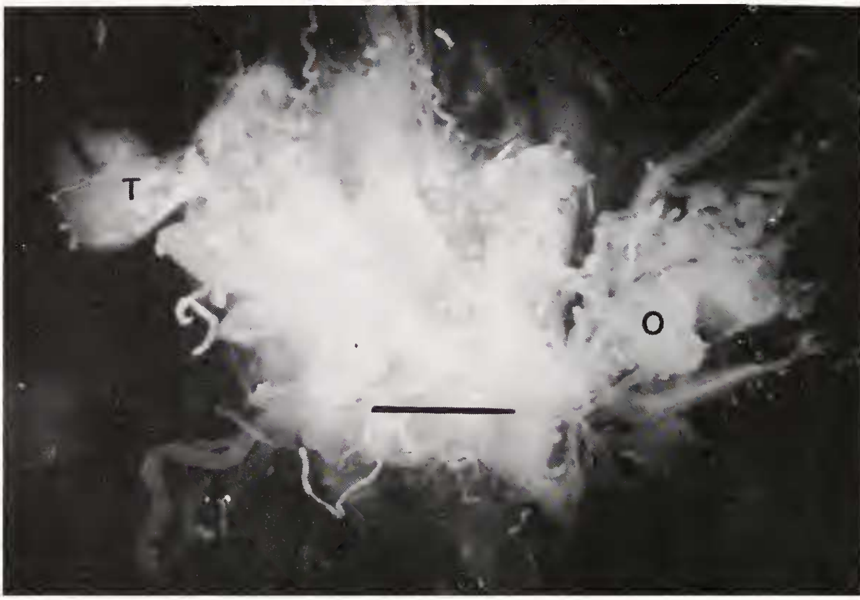

Fig. 2 Reproductive organs of the gynandromorph (Note the testis (T) on the left side and the ovary (O) on the right side, the opposite placement of the wing pattern) (Scale line = 2.0 mm).

DISCUSSION

Females of Lepidoptera are heterogametic (ZW) whereas males are homogametic (ZZ). The chromosomal constitution of eggs, rather than the sperm cells, determine the sex of the progeny. Gynandromorphs may arise due to loss of the Z chromosome during early zygotic divisions or due to double fertilization of binucleate (ZW) eggs. The loss of a Z chromosome in ZZ zygotes is a major cause of gynandromorphism (Robinson, 1971). This results in an embryo that is both female (ZO) and male (ZZ). The gynandromorph noticed in this study is an interesting case and deserves careful analysis. We found no reference to such a condition in the literature on gynandromorphs.

Mitotic spindle orientation at the first zygotic division is always random. In *D. melanogaster* subsequent mitotic products of the first two daughter nuclei do not intermingle before they migrate to the cellular blastoderm. Consequently, a half male/female gynandromorph shows large contiguous patches of male/female tissue, whose pattern of distribution is governed by the orientation of the first zygotic spindle. A left versus right symmetrical distribution of male versus female cuticular tissue in this *H. armigera* gynandromorph specimen demonstrates that early blastoderm cells in *H. armigera* do not intermingle as in *D. melanogaster.*

Gynandromorphs are powerful tools for following the clonal history of cells and producing fate maps of the blastoderm (Hotta and Benzer, 1972). The adult wings are derived from wing imaginal discs while the male and female somatic reproductive structures are mesodermal in origin. Ferrus and Kankel (1981), in a mosaic analysis of cuticular and muscular tissues in *D. melanogaster,* showed that wing epithelial cells often attach to clonally unrelated muscle cells. Even though the converse was not stated by Ferrus and Kankel (1981), it implies that clonally unrelated cells come to occupy extrinsically-related positions due to extensive cell movement in *Drosophila* during embryogenesis. Comparatively little is known about embryogenesis and morphogenetic movements in *Helicoverpa*. Considering that male and female reproductive cells of mesodermal origin occupy positions trans-lateral to clonally-related epidermal cells in our *H. armigera* gynandromorph specimen, we conclude that similar extensive cell movements occur in *H. armigera* during mesodermal differentiation also.

The influence of pesticidal molecules, including plumbagin, on epistatic sex determination has not been well-studied. Intersexes arise due to disturbances of the epistatic relationship between male and female determining genes during development. Such forms are common in *Aedes* sp. exposed to higher temperatures and in *Lymantria dispar* when genetically distinct strains are crossed (Richards and Davies, 1977).

Therefore, the insect under study can at the best be regarded as a natural gynandromorph occurring at an extremely low frequency (0.000125%, i.e., one out of 8000 insects reared so far), as also observed in *N. quernaria* by Kutis and Heppner (1990) and in *H. melpomene* by Emmel and Boender (1990).

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SOCIETY MEETING OF APRIL 22, 1998

Andrew Short
Glasgow High School/Univesity of Delaware

ENGINEERED STREAM SYSTEMS AS TOOLS FOR MACROINVERTEBRATE RESEARCH

Mr. Short has done research on the effects of elevated nutrient levels on benthic macroinvertebrates. He has designed and used artificial stream systems that are capable of maintaining extended pristine conditions. He received the Society's Calvert Award in 1996 for his work.

In the first part of his talk, Short discusssed the uses of artificial streams in dealing with riparian ecosystems as well as their applications in macroinvertebrate studies. Designs of his own stream systems were shown along with designs from Stroud Water Research Center and other engineered environments. Construction materials and methods for engineered environment construction were presented. Procedures for the collection of sediments and organisms, such as community block injection, and system operation were also given. Short described the function and uses of algal turf scrubber technology as an advisable alternative to other water filters and purifiers.

During the second part of this talk, Short presented his current research on the effects of elevated nutrient levels on benthic macroinvertebrates in artificial streams. Short outlined the procedures for data collection in the engineered systems. He discussed his results, in which certain populations of macroinvertebrates, primarily Trichoptera: Hypopsychidae, experienced significant declines over control populations, immediately after nutrient elevation. The nutrient factors used in the initial trials were nitrate nitrogen and soluble phosphorus, in concentrations consistent with poultry manure runoff that might be experienced regionally as a consequence of current agricultural practices. These population declines took place without the effects of eutrophication taking place. In subsequent trials, nitrate nitrogen elevation alone showed no negative effect on similar macroinvertebrate populations.

– W. J. Cromartie,
Correspnding Secretary